Hans Grassegger

VON KEMPELEN AND THE PHYSIOLOGY OF SPEECH PRODUCTION

1. INTRODUCTION

Wolfgang von Kempelen, a Hungarian nobleman in the Imperial Service at the court of Austria-Hungary, who was born in 1734 in Bratislava and died in 1804 in Vienna, was a talented engineer and inventor. He is known as the designer of the fountains of Schönbrunn palace, as well as of the plans of the royal castle of Buda, and as organiser of a wool factory in Hungary.[1]

But above all he was the inventor of two famous machines: the first one is the so called *Chess Playing Turk* (1769), a "mechanical" chessplaying automaton, developed and constructed in six months. This machine, a large cabinet with a chess board on top, was exhibited in many countries of Europe and in the United States. However, it was a complete fake as its success depended on the skills of an expert chess player concealed in the cabinet. Although Kempelen never claimed the chessplayer to be a real automaton, its trickery "mechanism" was never officially revealed. The second much more seriously designed invention was the *Speaking Machine* (1791), based on about two decades of scientific investigations in human speech production, and described to the last detail in his renowned book *Mechanismus der menschlichen Sprache*. In this context it seems worth mentioning an amusing novel by A. Kurzweil (1992), the protagonist of which is an inventor, living in the 18th century and trying to construct a *Speaking Turk* (!).

Although Kempelen's speaking machine had no predecessor it perfectly met the spirit of the 18th century, the beginning of the so called *golden era of automatons*. At that time the work of an ancient Greek mathematician, engineer and constructor of mechanical and hydraulic automatons, Heron of Alexandria, was rediscovered inspiring several inventors for sophisticated constructions of any kind. Among these there was the *flute player* (1736) and the *automatic duck* (1738) by the Frenchman Jacques de Vaucanson (1709–1782), which were the results of – nontheless failed – efforts in building a speaking machine.[2]

Whereas most of the automatons like playful clockworks and artificial singing birds were merely designed to amaze and amuse people, the endeavor to imitate human speech by mechanical processes in that period was rather due to a generally increasing scientific

1 For biographical details see e. g. the obituary by Kempelen's contemporary J.K. Unger reprinted in Brekle (1970: VII–XI), and the paper by Imre in this volume.

2 cf. Köster (1973: 55 ff.), Chapuis/Gélis (1928), Chapuis/Droz (1958).

curiosity for the comprehension and imitation of natural phenomena. As the physiological mechanisms of speech became fair targets of study basic research on the physiology of the human vocal apparatus led, not surprisingly, to the development of quite complicated mechanical devices that were intended to give proofs of the assumed functioning of the human vocal organs. Thus, the more or less successful construction of these first mechanical speaking machines[3] required thorough knowledge of relevant anatomical structures and physiological processes and a considerable amount of theoretical insights.

Consequently, the description of the speaking machine and the account of how Kempelen arrived at its final design forms only a relatively small part (actually the last, fifth chapter entitled *Von der Sprachmaschine*, pp. 388–456) of his famous book. Nevertheless, the instructions and illustrations given in this chapter were so elaborated that in the following centuries several replicae have been built.[4] However, the speaking machine did not only result from skilfull, empirical work but also from sound theoretical background knowledge, which Kempelen exposes in the four preceding chapters of his *Mechanismus der menschlichen Sprache*. Here he summarizes the contents of his intensive studies on language in general and on the nature of speech. The relative amount of space Kempelen devotes to different topics might reflect the significance he attaches to the scientific discussion on language and speech at his time. In the first two chapters (about 12 % of the total number of pages of the book) he discusses questions such as nature and origin of language, as well as affinity of languages. The third chapter (about 26 %) covers the anatomy and physiology of speech organs, whereas the fourth chapter (about 46 %, i. e. almost half of the book) deals with the particular speech sounds (or letters, as Kempelen puts it). Only about 15 % of the book are dedicated to the detailed description of the *Speaking Machine* in the fifth chapter (cf. *Figure 1*).

The present paper is going to concentrate on aspects which demonstrate the embedding of Kempelen's work within the *history* of phonetics as well as of linguistics. This will result in a short summary of linguistics in the 18th century with Kempelen's relevant reflections, and in a more detailed survey of sources, achievements and influence of Kempelen's physiology of speech production.

3 See e. g. Köster (1973: 6 ff.) for a detailed account of the first anthropomorphic, articulatory approaches to speech synthesis by the contemporaries KRATZENSTEIN, MICAL, and KEMPELEN.

4 see e. g. Liénard (1967), van den Broecke (1983), and Nikléczy/Olaszy (in this volume).

Speaking Machines

DUDLEY (1937)

FABER (1835)

KRATZENSTEIN (1780)
ABBÉ MICAL (1783)

VAUCANSON (1736)

Replicae

NIKLECZY/OLASZY
VAN DEN BROECKE
LIENARD
WHEATSTONE

Origin of Language

ROUSSEAU (1712-1778)
CONDILLAC (1715-1780)

DE BROSSES (1709-1777)
C. DE GEBELIN [1775]
HERDER (1744-1803)
SÜSSMILCH (1707-1767)
MONBODDO (1714-1799)

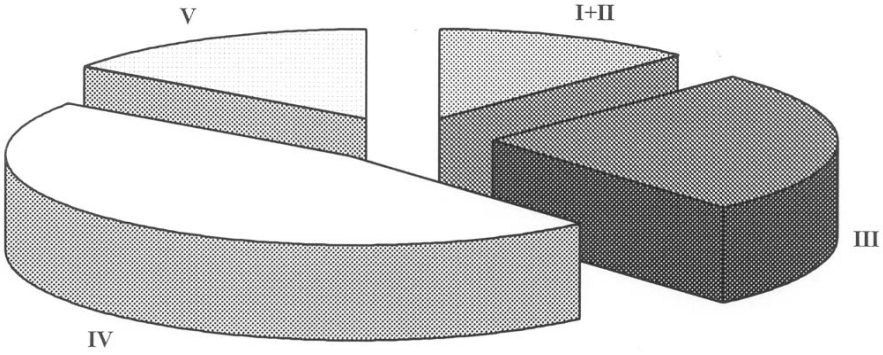
Comparison of Lang.

W. JONES
N. B. HALHEAD
P. J. SAJNOVICS
S. GYARMATHI

P.S. PALLAS
L. HERVÁS Y PANDURO
J.CH. ADELUNG

V. VON DER SPRACHMASCHINE

I. VON DER SPRACHE ÜBERHAUPT
II. ÜBER DEN URSPRUNG DER SPRACHEN



IV. VON DEN LAUTEN ODER BUCHSTABEN

III. VON DEN WERK-ZEUGEN DER SPRACHE

Acoustic theories of articulation

W. WILLIS
C. WHEATSTONE
H. HELMHOLTZ
L. HERMANN
C. STUMPF
T. CHIBA & M. KAYAMA
G. FANT
G. UNGEHEUER

Physiology of Speech - Phonetics

CONRAD AMMAN (1669-1730)
DENIS DODART (1634-1707)
ANTOINE FERREIN (1693-1769)
KARL MORITZ RAPP (1803-1883)
CARL L. MERKEL [1857/1866]
JOHANNES MÜLLER (1801-1858)
ERNST BRÜCKE (1819-1892)
ERNST SIEVERS (1850-1932)

Figure 1: Embedding of Kempelen's "Mechanismus…" in the history of linguistics and phonetics with a graph showing the relative amount of space dedicated to different topics.

2. Linguistics in the 18th Century

The eighteenth century was not only the century of automatons but also demonstrated a vital interest in the origin of language. In the first two chapters of his book, entitled *Von der Sprache überhaupt* (pp. 1–28), *Gedanken über die Fragen: ob die Sprachen von Menschen erfunden, oder ob sie ihnen anerschaffen worden ist? Ob alle Sprachen aus Einer Grundsprache entstanden sind?* (pp. 28–56) Kempelen gives a critical survey of the relevant scientific discussion referring to publications of Court de Gébelin, Charles de Brosses, James Burnett (Lord) Monboddo, Johannes Peter Süssmilch and Johann Gottfried Herder.[5]

The main issue of these publications was the question of the divine or human origin of language, a question debated in that century with greater zeal and frequency than ever before. It proves Kempelen's learnedness that he contributes some own ideas which he himself modestly qualifies as "zufällige Gedanken" (Vorerinnerung, p. 6).

In this context Kempelen adopts the view of a purely human origin of language, but he rigorously contradicts the traditional monogenetic theory of all languages. From a comparison of cardinal numbers in a series of languages he concludes:

> "So wenig der Apfelbaum, die Eiche oder die Linde aus der Tanne hervorgekeimt ist, so wenig können alle diese 120 Zahlwörter aus 10 Wörtern einer Ursprache herausgestimmelt worden seyn. Ist unter allen bisher angeführten Wörtern nur eines, das nicht aus der Ursprache herausgekünstelt, sondern irgendwo von einer menschlichen Gesellschaft erfunden worden, so können auch hundert – so können tausend, – so kann eine ganze Sprache erfunden worden seyn." (p. 43 f.)

Another important topic in linguistic historiography is the especial trend of empirical linguistics in that time that consisted of word-collecting and comparison of languages as a means of historical research. This trend dates back to the 17th century, when languages were compared and classified in accordance with their similarities, mainly still to prove that they derive from Hebrew, thought by many to have been the original language (and thus proving the divine origin of language).

During the eighteenth century, however, it was the growing political and economic interest of the developing Empires, like Russia, England, and Spain that yielded voluminous collections of language data e. g. those of P.S. Pallas, L. Hervás y Panduro and Johann Christoph Adelung. The latter is extensively quoted by Kempelen (pp. 51–54) –

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5 A. Court de Gébelin (1775) *Monde primitif. Origine du langage*, Paris; Charles de Brosses (1765) *Traité de la formation mécanique des langues et des principes physiques de l'étymologie*, Paris; Johannes Peter Süssmilch (1766) *Versuch eines Beweises, dass die erste Sprache ihren Ursprung nicht vom Menschen, sondern allein vom Schöpfer erhalten habe*, Berlin; Johann Gottfried Herder (1789) *Abhandlung über den Ursprung der Sprache*, Berlin; James Burnett (Lord) Monboddo (1774–92) *Of the origin and progress of language* (6 vols.), Edinborough.

presumably from ADELUNG'S *Über den Ursprung der Sprachen …*, although Kempelen does not give any details about the source.[6]

Concluding this rather selective survey of linguistics in the 18th century it seems worth mentioning, that during Kempelen's life time there were some other important achievements concerning the affinity of languages, like the well-known observations of SIR WILLIAM JONES and of NATHANIEL BRESSEY HALHEAD on the structural similarities of Sanskrit and European languages, as well as the convincing arguments of PATER JOHANNES SAJNOVICS and later on of SÁMUEL GYARMATHI on the genetic relationship between Finno-Ugric languages and Hungarian.[7]

Kempelen himself (pp. 31 ff.) makes use of his knowledge of Hungarian to argue against the view of a monogenetic theory of all languages. A comparative list of Hungarian and German nouns, adjectives, adverbs and verbs is given (pp. 36–39) to prove the independence of the two languages, i. e. the absence of a common linguistic origin.

Moreover, critisizing the simple paradigm of word-collecting Kempelen claims the importance of morphological and syntactic criteria and properties in the comparison of languages. Based on these higher levels of linguistic description he again depicts the typological difference between most European languages on the one hand and Hungarian on the other (pp. 45–48). However, Kempelen's conclusion reads less scientifically:

> "Wer je Ungarn sprechen gehört hat, wird bekennen, daß schon ihr körniger Ausdruck und der heroische Klang der Rede sich von allen anderen Sprachen unterscheidet." (p. 48)

3. PHYSIOLOGY OF SPEECH

3.1. Introductory remarks

Kempelen's book contains an impressively detailed treatise of the physiology of speech production. In the third chapter (*Von den Werkzeugen der Sprache und ihren Verrichtungen*, pp. 57–177) he thoroughly deals with the speech organs, whereas in the fourth chapter (*Von den Lauten oder Buchstaben der europäischen Sprachen*, pp. 178–387) he gives an elaborate account of what he calls "Hauptalphabet" (universal alphabet). By the way, these

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6 P.S. PALLAS (1786-89) *Linguarum totius orbis vocabularia comparativa*, St. Petersburg; LORENZO HERVÁS Y PANDURO (1800/05) *Katalog der Sprachen der bekannten Völker …* (6 Bände); JOHANN CHRISTOPH ADELUNG (1781) *Über den Ursprung der Sprachen und den Bau der Wörter, besonders der deutschen*, Leipzig.

7 SIR WILLIAM JONES (1788) *Asiatic Research*; NATHANIEL BRESSEY HALHEAD (1778) *Bengal Grammar*; PATER JOHANNES SAJNOVICS (1770) *Demonstratio idioma Ungarorum et Lapponum idem esse*, Kopenhagen; SÁMUEL GYARMATHI (1799) *Affinitas linguae Hungaricae cum linguis fennicae originis grammatice demonstrata*, Göttingen.

two chapters make up about three quarters of the 456 pages of his *Mechanismus der menschlichen Sprache*.

Although early descriptions of the anatomy of the human vocal tract date back to Aristotle, it was the revolution of modern natural sciences which lead to a serious development of physiological research. Kempelen contributed many innovative observations to this rather new field, not without repeatedly referring to predecessors or contemporaneous scholars whose achievements and opinions Kempelen either incorporates in his text or critically comments on.

Far from intending an exhaustive specification of Kempelen's scientific sources as far as anatomy and physiology of the speech organs are concerned, we will go through the relevant chapters of Kempelen's book indicating some topics of interest.

3.2. Speech organs

To begin with, according to Kempelen, the main speech organs are: 1. the glottis, 2. the nose with the velum, 3. the mouth, 4. the tongue, 5. the teeth, and 6. the lips; whereas the voice producing mechanism consists of 1. the lungs, 2. the trachea, 3. the larynx (*Luftröhrenkopf*), and 4. the glottis. Essentially, these are the same descriptive parameters as used in modern articulatory phonetics. Thus, Kempelen overcomes older theories of speech production, which ascribe primary function to the larynx and (only) secondary function to the vocal tract.

Well aware of the importance of the anatomy and physiology of the above mentioned voice and speech producing organs, Kempelen sets out to describe each component as to its structure, function and effect in speech production:

> "… so soll hier bey jeden zur Sprache beytragenden Werkzeuge das Nothwendigste von seiner Struktur, Bestimmung und Wirkung gesagt werden." (p. 58)

These (anatomical and physiological) descriptions are mainly based on the third volume of ALBRECHT VON HALLER'S *Elementa physiologiae*, dealing with respiration and voice[8] (cf. pp. 57, 61, 79), but there are also other citations of HALLER'S voluminous work,[9] as e. g. the description of the tongue, which Kempelen quotes at length (pp. 132–134) from a German translation.

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8 ALBRECHT VON HALLER (1751-66) *Elementa physiologiae corporis humani*; 3rd vol. 1761: *respiratio, vox*, Lausanne

9 Cf. Zwirner/Zwirner (1966: 50): "In ALBRECHT VON HALLER wurde – eigentlich zum ersten Mal seit GALEN – das riesige, seit VESAL in Anatomie und Physiologie aufgehäufte Wissen in einem großen Gebäude zusammengefaßt."

As far as the trachea and its contribution to the production of speech is concerned Kempelen rightly reduces its function to the task of air transport from the lungs to the larynx. In this respect he rejects older views on voice generating effects of the trachea, like e. g. those of the Greek GALENUS[10], whom Kempelen explicitly mentions in this context (p. 74). Interestingly enough, Kempelen frankly reports on his own – erroneous – observations of a trembling trachea, which he felt when putting a finger on his chest during speaking:

> "Auch ich war … immer auf diesem Irrwege. Wenn ich unter dem Sprechen den Finger gleich ober dem Brustbein an die Luftröhre hielt, so fühlte ich ihr Zittern offenbar. Dieß hielt mich immer bey dem Gedanken feste, daß man einen solchen zitternden Schlauch nachahmen müßte, wenn man durch eine Maschine sprechen wollte." (p. 71)

It was the French physiologist DENIS DODART[11] whom Kempelen owes the final insight, that this trembling of the trachea was not the cause but the effect of the vibrations of air during speaking. Consequently, Kempelen identifies the larynx as the source of human voice ("Sitz der Stimme", p. 73) and the glottis as voice generating mechanism (p. 81). In regard to these structures there a two aspects in Kempelen's writings, which deserve special attention.

Firstly, Kempelen points out the motion of the larynx, which raises and lowers during speaking (p. 73). However, the resulting change of the vocal tract length is not taken into further consideration, neither in his theoretical reflections nor in the construction of the speaking machine.[12]

Secondly, in discussing the mechanism of phonation, this is the functioning of the vocal chords, Kempelen attempts to reconcile two theories already existing at that time: the conception of the larynx as a wind instrument by DENIS DODART and as a (bowed) string instrument of ANTOINE FERREIN (1741).[13]

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10 By the way: GALENUS (2nd century A.D.) and LEONARDO DA VINCI'S *Quaderni d'anatomia* are frequently mentioned as ancient pioneers in the history of phonetics. However, GALEN'S observations have fallen into oblivion, and DA VINCI'S writings and drawings were not yet (re)discovered in the 18th century (cf. Panconcelli-Calzia 1941: 21 and 1940: 10).

11 DENIS DODART (1703) *Memoires sur les causes de la voix de l'homme et de ses différents tons*, Paris. Kempelen (p. 71) erroneously cites: "… sur la formation de la voix …".

12 Modern cineradiographic studies confirm "an interaction of the height of the larynx, degree of opening of the mandible, and protrusion of the lips" (Perkell, 1969: 65) in controlling vocal-tract length for all vowels. See also Kempelen's physiologic-acoustic parameters of vowel description ("Öffnung des Mundes und Öffnung des Zungenkanals", p. 194), where the second parameter includes the moving of the larynx (p. 196). This interaction is also corroborated by Perkell (1969: 63), as already Brekle/Wildgen (1970: XXX* ff.) have pointed out.

13 In *Recueil de l'académie de science de Paris* (1741) FERREIN reports on experiments on the excised larynx of a human corpse (about 250 years after LEONARDO DA VINCI, without knowing about his writings; cf. Panconcelli-Calzia 1941: 37).

> "Allein beyde Meinungen lassen sich vereinbaren … Denn es kann an der Stimmritze keine Veränderung vorgehn, das ist, sie kann nicht weiter oder enger werden, ohne daß ihre Ränder auf- oder abgespannt werden, und so umgekehrt, können sich die Ränder nie mehr oder weniger spannen, es seye denn die Stimmritze werde zugleich enger oder weiter. Und so steht die Ferreinsche Spannung und die Dodartsche Öffnung unzertrennlich beysammen. Die Eine ist zur Stimme so notwendig als die andere." (p. 82)

Nevertheless, in his three versions of the speaking machine Kempelen never used a membraneous pipe as a sound generator, which is – as Köster (1973: 99) puts it – "ein Zeichen dafür, daß sich die theoretisch falsch angesetzte künstliche Glottis in der Praxis nicht bewährte". Thus Kempelen's practical approach was not only due to technical constraints but resulted also from an evident misinterpretation of the natural voice generator.[14]

In the subsequent sections Kempelen provides an exhaustive account of the supralaryngeal structures involved in the production of speech sounds.

The anatomical description of the nasal cavity is completed by a detailed explication of the velum and its (valve) function at the velopharyngeal port.

The vocal tract is treated at length and special attention is given to the tongue. As to its anatomy Kempelen refers to the relevant passages of ALBRECHT VON HALLER'S *Elementa physiologiae* – as already mentioned above. As to the articulatory importance of the tongue Kempelen recognizes it as the main tool to modify the pulmonic airstream and involved in the production of all speech sounds.

> "So, wie die Luft, oder die Stimme der Hauptstoff zur Sprache ist, so ist die Zunge das Hauptwerkzeug diesen Stoff zu bearbeiten und auszubilden. Es sind nur wenige Laute oder Buchstaben bey denen sie müßig bliebe." (p. 135)

Much space (pp. 143–148), however, is granted to critisise HELMONT'S odd claim, that position and shape of the tongue in the formation of speech sounds is reflected in the original shape of Hebrew letters, thus again stressing Hebrew as *lingua sacra* and as the origin of all languages – as was believed by some scholars still by the end of the 17th century.[15] Reproductions of HELMONT'S copperplate drawings of puzzling tongue shapes e. g. in bilabial articulations (*mem* and *beth*) are rejected by Kempelen (p. 144) as resulting from an excited phantasy.

However, Kempelen obviously was not aware of the more serious work of the English bishop JOHN WILKINS,[16] who in 1668 presented a kind of transcription, where articulatory properties of a sound are reflected in the shape of the corresponding letter, an approach further developed two centuries later in ALEXANDER MELVILLE BELL'S universal phonetic

14 Here it ought to be mentioned that laryngoscopic techniques did not emerge before the second half of the 19th century with the observations of M. GARCIA and J.N. CZERMAK (cf. Panconcelli-Calzia 1940: 29 f.).

15 F. M. B. VON HELMONT (1667) *Alphabeti vere naturalis hebraici brevissima delineatio* …, Sulzbach.

16 JOHN WILKINS (1668) *An essay towards a real character and a philosophical language*, London.

alphabet of speech gestures[17] and – with modern acoustic instrumentation – by POTTER, KOPP, and GREEN[18].

On a whole, in his chapter on "articulatory phonetics", as *Von den Werkzeugen der Sprache* could be entitled nowadays, Kempelen impressively demonstrates his profound knowledge of the anatomy and physiology of the speech organs. He does not only recognize and emphasize the tripartite structure of speech production (i. e. initiation, phonation and articulation) and discuss their particular contribution to the production of speech sounds, but also gives detailed descriptions of their mode of action in generating non-linguistic human sounds, such as snoring, hawking, coughing, sneezing (p. 112 ff.), clicking (p. 136 f.), and even kissing is treated at length (p. 170 ff.):

> "Wie man küßt, weiß der ganze Erdboden, aber wie der dem Ohre so willkommene Laut dabey entsteht, daran dürfte wohl ein großer Theil nie gedacht haben." (p. 170 f.)

The purpose of this account of seemingly non-speech sounds is explicitly stated as an attempt to give a universal inventory of possible speech sounds:

> "… und vielleicht ein Theil der von mir angeführten Schallen, und noch manche andere, die meiner Aufmerksamkeit entgangen sind, bey unbekannten Völkern wirkliche Bestandtheile ihrer Sprache ausmachen." (p. 176)

This tendency to universalism reflects a main stream concept of the 18th century, and can be found throughout Kempelen's work, beginning with the definition of human language against that of animals in chapter I, extending over physiological universals with numerous comparative remarks on human and animal vocal physiology in chapter III as well as including a universal alphabet in chapter IV, and finally reaching to the confidently uttered expectation that his speaking machine – once refined and perfected by some interested successors (p. 396) – would become "eine alles sprechende Maschine" (p. 389).

3.3. Universal alphabet

Although in chapter IV *Von den Lauten oder Buchstaben der europäischen Sprachen* Kempelen's ideas of articulatory universals of speech become fully effective, I am not going to discuss that chapter in detail for two reasons: firstly, because his theory of vowel articulation is dealt with in another contribution to this volume (see Pompino-Marschall), and secondly, because Kempelen's classification and description of consonants would deserve an investigation all its own (see Grassegger, in prep.).

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17 ALEXANDER MELVILLE BELL (1867) *Visible Speech – the Science of Universal Alphabetics*, New York.

18 POTTER, R.K./KOPP, G.A./GREEN, H. (1947) *Visible Speech*, New York.

Thus, suffice it to recall that Kempelen was the first to propose a universal classification of vowels by two articulatory parameters,[19] and the first to classify groups of consonants according to the two binary features [± voice] ("Stimme") and [± fricative] ("Wind").

Nevertheless, Kempelen still uses *letters* (of the Latin alphabet) as a basis of his classification of sounds. Although letters designating sounds or combinations of sounds already defined, like *q* (for *k*) or *x* (for *ks*) are omitted and combinations of letters designating simple sounds, like *ch* (for [x, ç]) or *sch* (for [ʃ]), are added, Kempelen does not really give any convincing argument for adopting his *Hauptalphabet*. Consequently, detailed and proper(!) descriptions of sounds not covered by distinct letters, such as e. g. palatal or velar nasals, are simply referred to as deviations from a letter(!) of the universal alphabet (i. e. in our example from *n*).

> "Man hat in der Natur viererley N, die in der Schrift zwar mit einerley Zeichen angedeutet, aber dennoch verschieden ausgesprochen werden. Wir wollen hier mit dem allgemeinen N, wie es in dem gewöhnlichen Alphabethe aller Sprachen lautet, den Anfang machen. Die übrigen drey sind nur Abweichungen ..." (p. 309 f.)

However, Kempelen is the less to blame for this inconsistency, as some thirty years later (1822) in the second edition of JAKOB GRIMM'S famous *Deutsche Grammatik*[20] a treatise of about 600 pages is still entitled *Von den Buchstaben*. This letter-oriented view of speech sounds and GRIMM'S obvious influence on comparative linguistics in those days is said to have stood in the way of phonetic progress for almost half a century.[21]

Thus, it seems that not even the voluminous work of one of GRIMM'S students, namely KARL MORITZ RAPP, *Versuch einer Physiologie der Sprache* (1st vol. 1836) had a substantial effect in this matter. RAPP, occasionally referring to Kempelen's work, tried to introduce physiological aspects into historical linguistics, as the full title of his book indicates.[22]

JAKOB GRIMM, in the third edition of the first volume of his *"Deutsche Grammatik"*, published in 1840, reacted somewhat ambiguously: on the one hand he continued to oppose against a merely physiological approach in dealing with speech sounds,[23] on the other hand he changed the title of his *Buchstabenlehre* to *Lautlehre*.

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19 The classification of vowels was later on elaborated and refined by JOST WINTELER and ERNST SIEVERS in Germany, as well as by ALEXANDER MELVILLE BELL and HENRY SWEET in England. CH.F. HELLWAG'S *De formatione loquelae* (1781) with its vowel triangle obviously was not known to Kempelen.

20 JAKOB GRIMM (1822) *Deutsche Grammatik*, Göttingen (vol. 1: 1819, revised edition 1822; vol. 2: 1826, vol. 3: 1831, vol. 4: 1837) – Vol. 1, third edition: 1840.

21 Cf. Panconcelli-Calzia (1941: 42 f.)

22 KARL MORITZ RAPP (1836–41), *Versuch einer Physiologie der Sprache nebst historischer Entwicklung der abendländischen Idiome nach physiologischen Grundsätzen*, Tübingen.

23 "Wenn man den Lauten rein physiologische Functionen unterschiebt ..., wird mir wenigstens die Luft allzu dünn, und ich vermag nicht darin zu leben", GRIMM (Deutsche Grammatik, vol. 1, 3rd ed. (1840), S. XV; cited from Zwirner/Zwirner 1966: 86).

3.4. From physiology to phonetics

This controversy between historical linguistics and physiology in the first half of the 19th century coincides with the publications of two important physiologists of that time.[24]

In 1857, CARL LUDWIG MERKEL published his voluminous *Anthropophonik*[25] which gives a thoroughly elaborated description of the anatomy of the speech organs and an equally detailed account of the physiology of speech-sound formation. In contrast to the huge amount of anatomical and physiological data actual speech phenomena and the phonetic classification of sounds are not dealt with in comparable detail[26]. Nevertheless, MERKEL holds the view, that the sound classes set up by him will cover all languages. Nine years later, in 1866, MERKEL'S *Physiologische Laletik*[27], an abridged and more convenient version of *Anthropophonik* dispenses with a great deal of anatomical details and gets more language-oriented, apparently influenced by ERNST BRÜCKE, the other great physiologist, whose *Grundzüge* (see next paragraph) MERKEL meanwhile has consulted as is demonstrated by quotations and critical remarks.

In 1856 (one year prior to MERKEL'S *Anthropophonik*) ERNST BRÜCKE published his *Grundzüge der Physiologie*, a rather slim volume that – skipping all the anatomical detail – aims at a comprehensive classification of linguistic sound elements.[28] With its exhaustive and accurate description of linguistically relevant properties of sounds BRÜCKE'S system was far superior to MERKEL'S and obviously made the latter revise his *Anthropophonik* to the *Physiologische Laletik* (as already mentioned above).

And it is BRÜCKES treatise to lead us back to our starting point, Wolfgang von Kempelen. Kempelen is repeatedly cited throughout BRÜCKE'S *Grundzüge*, in the description of vowel production (p. 13) as well as in the discussion of plosive voicing (p. 33), in com-

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24 In the same period the founder of modern physiology, JOHANNES MÜLLER, prepared his *Lehrbuch der Physiologie* (Müller/1838/III) with an important chapter on voice and speech (cf. Köster 1973: 149).

25 CARL LUDWIG MERKEL (1857) *Anatomie und Physiologie des menschlichen Stimm- und Sprach-Organs (Anthropophonik): Nach eigenen Beobachtungen und Versuchen wissenschaftlich begründet und für Studierende und ausübende Ärzte, Physiologen, Akustiker, Sänger, Gesanglehrer, Tonsetzer, öffentliche Redner, Pädagogen und Sprachforscher dargestellt*, Leipzig.

26 For a brief summary of shortcomings in Merkel's systematisation of speech sounds see e. g. Kohler (1981: 166).

27 CARL LUDWIG MERKEL (1866) *Physiologie der menschlichen Sprache (physiologische Laletik)* – According to Malmberg (1976: 194, fn. 9), the term *Laletik* was used here for the first time and did not reappear until the twenties of the last century, when Jørgen Forchhammer introduced it to designate the science of speech ("Sprechkunde"): cf. Jørgen Forchhammer (1951) *Allgemeine Sprechkunde (Laletik)*, Heidelberg.

28 ERNST BRÜCKE (1856) *Grundzüge der Physiologie und Systematik der Sprachlaute für Linguisten und Taubstummenlehrer*, Wien (republished in 1876).

ments on nasalization of vowels (p. 50) and even in the exemplifications of what one nowadays would call atypical articulations (like e. g. labio-dental plosives; p. 34). In a historical survey of systematic classifications of speech sounds (beginning with John Wallis[29]) BRÜCKE explicitly acknowledges Kempelen's classification of consonants for its new categorization according to voice and friction noise.

> "… interessant, dass hier das gegenseitige Verhältnis von Stimme und eigenem Geräusch der Consonanten als wesentlicher Eintheilungsgrund auftritt und dadurch eine Beziehung zwischen Medien und Liquiden aufgedeckt wird, die in anderen Systemen weniger zu Tage liegt." (p.104)

It must be emphasized that neither Kempelen nor BRÜCKE (nor MERKEL) were primarily interested in language specific sounds. They were rather searching for the natural laws by which human speech is conditioned. Evidently, not all the different speech sounds do occur in all languages, but all these sounds can be produced by all human beings because of the similarity of their vocal organs. Consequently, the physiological analysis of these potential and actually used sounds in language is the principal task requiring detailed study of anatomical facts and physiological processes.

In fulfilling this task – intermediate between CONRAD AMMAN'S *Dissertatio de loquela* (1700)[30] and, say ERNST SIEVERS, whose *Grundzüge der Lautphysiologie* (1876)[31] was renamed *Grundzüge der Phonetik*(!) in the 2nd edition of 1881, Wolfgang von Kempelen made a most important step as BRÜCKE enthusiastically confirms in his well known appraisal:

> "Im übrigen aber kann man sagen, dass Kempelen uns eine physiologische Lautlehre hinterlassen hat, … die … so fest begründet war, dass sie den sichersten Unterbau für alle ferneren Forschungen gegeben hat und geben wird. Sein Werk … ist eines der besten physiologischen Bücher, welche ich je gelesen habe …" (p. 6)

Thus NEWTON'S famous saying well applies to Wolfgang von Kempelen's impact on phonetic sciences: *We are where we are, because we stand on the backs of giants.*

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29 JOHN WALLIS (1653) *De loquela, sive sonorum formatione, tractatus grammatico-physicus*, Oxonia.

30 CONRAD AMMAN (1700) *Dissertatio de loquela*, Amsterdam.

31 ERNST SIEVERS (1881) *Grundzüge der Phonetik zur Einführung in das Studium der Lautlehre der indogermanischen Sprachen*, Leipzig (2nd edition of *Grundzüge der Lautphysiologie*, Leipzig 1876).

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